United States
Department of
Agriculture

Cooperative State
Research, Education,
and Extension Service

Competitive Research
Grants and Awards
Management

NRI Annual Report: Fiscal Year 1999

National Research Initiative Competitive Grants Program

"Knowledge for Tomorrow's Solutions"

www.reeusda.gov/nri
202/401-5022
nricgp@reeusda.gov

This annual report and other NRI materials such as *Abstracts of Funded Research*, the *2000 NRI Program Description*, *NRI Research Highlights*, and *NRI Cover Stories* are available on the NRI home page (www.reeusda.gov/nri). For more information about the NRI, write or call the National Research Initiative Competitive Grants Program, Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, Mail Stop 2241, 1400 Independence Ave., SW, Washington, DC 20250-2241; 202/401-5022; nricgp@reeusda.gov.

January 2000

United States
Department of
Agriculture

Cooperative State
Research, Education,
and Extension Service

Competitive Research
Grants and Awards
Management

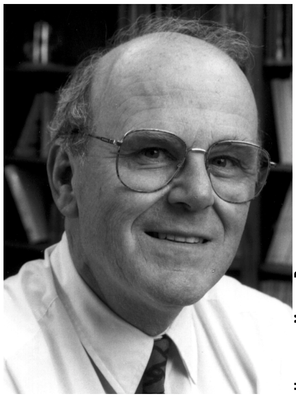
NRI Annual Report: Fiscal Year 1999

National Research Initiative Competitive Grants Program

“Knowledge for Tomorrow’s Solutions”

Contents

Message From the NRI Chief Scientist



University of Missouri Photo

Dear Colleagues:

Fiscal year (FY) 1999 was an unexpectedly bright one for the National Research Initiative (NRI) Competitive Grants Program. Congress appropriated an approximate 25% increase for the funding base to $119.3 million – still well short of the $500 million authorized in the 1990 Farm Bill but a step forward after years of stagnation at or below $100 million. Fortunately, the Plant Genome Program, first funded in FY 1998 through the National Science Foundation (NSF), and the improved appropriation to the NRI in FY 1999 have provided a more optimistic signal to researchers. Let us hope that the furor over genetic modification of plants through molecular techniques does not sour the public and political mood so much that the momentum in research funding for agriculture is lost.

How have the increased appropriations been used? First, it has been possible to increase the size of top-rated proposals. In that way research projects can be completed and not left half-finished as a result of crippling budget reductions. Unfortunately, this policy has a downside. No more proposals could be funded in FY 1999 than in FY 1998, despite the better NRI budget. This year, for example, a total of 690 grants were made, fewer than last year. Second, it was thought that a number of important areas of national concern had to be addressed. Our stakeholders, the Administration, and the Congress each had made it clear that food safety was a national priority. Of the additional $8 million appropriated by Congress for this area, we targeted $5 million for large multi-disciplinary grants to tackle epidemiological aspects of food safety from farm to table. Fifty-two proposals were received in response to this new program, and nine were funded. Grants ranged up to $885,000, an award amount unprecedented in the history of the NRI, but needed if the research were to be effective.

Reasoning that much of the agricultural research projected to occur over the first decades of the 21st century will be driven by our knowledge of plant, animal, and microbial genomes, the NRI decided to invest additional monies into genome efforts. Of the $5 million increase in the Animals Division, $3 million was set aside to start a fledgling Animal Genome Initiative. Here the intention has been and will continue to be the provision of “tools,” such as ESTs (expressed sequence tags), libraries, and improved genome maps, for scientists interested in the genetics of farmed species. Again, the five grants awarded in 1999 have been large by NRI standards. The Plants Division dedicated $2 million annually to fund the U.S. component of the international effort to sequence the entire rice genome. These monies were matched with an equivalent amount from NSF and a smaller sum from the Department of Energy (DOE) to tackle chromosome 10. Two grants totaling more than $12 million over 3 years were awarded. It is my hope that such types of interagency cooperation, which avoids overlap and the cost of dual review, will become models as other areas of common interest are explored.

Finally, the NRI was able to double the appropriations for Agricultural Systems, a multidisciplinary program that supports studies on the interactions among the component parts of the agricultural system and provides assessments on how well agriculture fulfills its societal goals.

The expansion of the NRI research portfolio in 1999 was achieved without any increase in the numbers of either scientific or clerical staff. There has been no upswing in administrative costs. The same fine peer-review process involving both *ad hoc* reviewers and assembled panels has remained in place for all proposals. We continue to fund according to panel recommendations and do not make “adjustments,” no matter how politically expedient that might be. I am truly proud of what the NRI has been able to achieve through this process. It is a small program within a large agency, but its accomplishments have been spectacular.

In the report that follows is an overview of some of the research the NRI will be supporting over the next 2 to 3 years from its FY 1999 appropriation. I have chosen to highlight just a few of the 690 grants funded. I have selected ones that seemed to me to have broad appeal and to exemplify the missions of the USDA. I have, for example, described several projects that address issues of current concern, such as the economic impact on rural communities of recent changes in agricultural practices and the threats to agriculture from invasive species. Our *Cover Stories* and *NRI Research Highlights* series provide other accounts of auspicious research funded by the NRI.

I have also included three other sections in the report. The public often forgets that research is a long-term enterprise and that any tangible benefits to the Nation can take years to emerge. Therefore, I have included two major success stories from the NRI-supported research. One describes the metabolic engineering enterprise of Dr. Lonnie Ingram; the other features the tissue culture work of Dr. Ron Phillips, which ultimately allowed genes to be transferred into elite lines of corn. Both, I think, illustrate how sustained effort, underpinned by long-term support, can pay off in a major way. Finally, we pay tribute to three NRI-funded investigators – Drs. Joanne Chory and James Womack, who were elected to the National Academy of Sciences in 1999, and Dr. Smita Mohanty, who received a Presidential Early Career Award for Scientists and Engineers.

I will close this letter by acknowledging the efforts of two long-term members of the NRI scientific staff, Dr. Anne Datko and Dr. Jane Smith, who both retired in 1999. Datko was Division Director for Natural Resources & the Environment; Smith directed the Nitrogen Fixation & Nitrogen Metabolism and Photosynthesis & Respiration Programs. Both were dedicated to the NRI and to the scientists their programs supported. They will be greatly missed.

R. Michael Roberts
NRI Chief Scientist

The National Research Initiative: Overview

USDA's National Research Initiative (NRI) was established in 1991 in response to recommendations outlined in *Investing in Research: A Proposal to Strengthen the Agricultural, Food and Environmental System,* a 1989 report by the National Research Council's (NRC) Board on Agriculture. This publication called for increased funding of high-priority research, funded by USDA through a competitive peer-review process, directed at:

- Increasing the competitiveness of U.S. agriculture.
- Improving human health and well-being through an abundant, safe, and high-quality food supply.
- Sustaining the quality and productivity of the natural resources upon which agriculture depends.

Continued interest in and support of the NRI is reflected in a second NRC report, *Investing in the National Research Initiative: An Update of the Competitive Grants Program of the U.S. Department of Agriculture,* published in 1994. In 1998, the NRC began a comprehensive evaluation of the NRI's progress and accomplishments. A report based on this evaluation is anticipated in 2000.

Competitive Review Process

The NRI competitive review process encourages innovative ideas that are likely to open fundamentally new research approaches to enhancing agriculture, food, forestry, and the environment. A proven mechanism for stimulating new scientific research, the process increases the likelihood that investigations addressing important, relevant topics using well-designed and well-organized experimental plans will be funded. Each year, panels of scientific peers meet to evaluate and recommend proposals based on scientific merit, investigator qualifications, and relevance of the proposed research to U.S. agriculture.

At least 10 percent of NRI funds support Agricultural Research Enhancement Awards. These awards enhance the U.S. agricultural research system through funding of postdoctoral fellowships and research by new investigators as well as through Strengthening Awards.

Strengthening Awards include the following categories: Research Career Enhancement Awards, Equipment Grants, Seed Grants, and Strengthening Standard Research Projects. These grants fund researchers at small and mid-sized institutions with limited institutional success or in states and other entities that are part of the Experimental Program for Stimulating Competitive Research (EPSCoR).

The NRI encourages multi-disciplinary research, which is needed to solve complex problems, and seeks to initiate research in new areas of science and engineering that are relevant to agriculture, food, forestry, and the environment. The NRI also supports scientific conferences to facilitate the exchange of information necessary to achieve the most rapid advances in these areas. Both mission-linked research and fundamental research are supported by the NRI. Mission-linked research targets specific problems, needs, or opportunities. Fundamental research – the quest for new knowledge about agriculturally important organisms, processes, systems, or products – opens new directions for mission-linked research. Both mission-linked research and fundamental research are essential to the sustainability of agriculture.

Policy

A Board of Directors, chaired by the USDA Under Secretary for Research, Education, and Economics (REE), provides oversight of NRI policy. Board members include the Administrators of the four agencies comprising the REE Mission Area – the Cooperative State Research, Education, and Extension Service (CSREES); the Agricultural Research Service (ARS); the Economic Research Service (ERS); and the National Agricultural Statistics Service (NASS) – as well as the Deputy Chief for Research of the Forest Service (FS) and the NRI Chief Scientist. The Deputy Administrator of CSREES' Competitive Research Grants and Awards Management Division serves as the Board's Executive Officer.

The Board of Directors oversees NRI policy by providing comments to the CSREES Administrator on the annual *NRI Program Description,* considering the recommendations made by the National Agricultural Research, Extension, Education, and Economics Advisory Board; identifying issues of importance to the NRI; providing a forum on future directions of the NRI; and fostering communication across relevant USDA research agencies regarding NRI programs and procedures.

Identification of Research Priorities

Setting research priorities is an important means of facilitating the scientific and technological advances needed to meet the challenges facing U.S. agriculture. Congress sets the basic budgetary framework for the programs of the NRI by providing funds in six priority categories (see section on Authorization, below). Members of Congress also make recommendations for the scientific and programmatic administration of the NRI through appropriation language and through their questions and comments during Congressional hearings.

Input into the priority-setting process is sought from a variety of NRI customers and stakeholders. The scientific community provides direction for the NRI through the research proposals it submits each year as well as through the research proposal evaluations and funding recommendations of individual scientific peer-review panels.

NRI scientific staff members play an important role in providing continuity of programmatic and scientific administration from year to year. Staff members attend scientific and professional meetings to stay current on scientific trends that need to be reflected in the *NRI Program Description* and in the coordination of priority setting with other Federal agencies. NRI staff also participate in meetings with representatives of key commodity groups and other user groups to discuss these stakeholders' current research priorities, learn ways the NRI can assist in meeting their needs, and solicit comments and suggestions on NRI research priorities.

Input from several coalitions has proved to be an important source of information. NRI staff members meet with groups such as the Institute of Food Technologists, CROPS99, CO-FARM, C-FARE, FAIR2002, and the Animal Agriculture Coalition to gain a broad perspective on current research needs and priorities.

The NRI Chief Scientist, the Deputy Administrator of the Competitive Research Grants and Awards Management unit, and NRI scientific staff are responsible for assimilating the input of diverse stakeholder groups into a program description that will solicit the highest quality proposals to meet the needs of U.S. agriculture. The NRI research areas, which are evaluated and updated each year, are included in the *NRI Program Description* issued annually.

The *NRI Program Description* is accessible to universities, Federal research laboratories, private research organizations, and individual scientists – both in printed form and on the Internet via the NRI home page (*www.reeusda.gov/nri*). In addition, the NRI receives comments on its programs from academic administrators, other staff members, and scientists from partner universities; the Experiment Station Committee on Policy; and the research administrators of the 1890 land-grant institutions.

Authorization

In the legislation that authorized the establishment of the NRI, Congress defines high-priority research as basic and applied research that focuses on both national and regional research needs (and methods for technology transfer) in the following areas:

- Plant Systems
- Animal Systems
- Nutrition, Food Quality, and Health
- Natural Resources and the Environment
- Engineering, New Products, and Processes
- Markets, Trade, and Policy

The authorizing legislation requires that, as appropriate, grants be consistent with the development of systems of sustainable agriculture. Congress further has specified that no less than 30 percent of funds be used to support multi-disciplinary team research, no less than 40 percent be used for mission-linked research, and no less than 10 percent be used to strengthen the research capacity of individuals and institutions.

Program Implementation

The *NRI Program Description* is distributed widely within the scientific community and among other interested groups. The fiscal year (FY) 1999 *NRI Program Description,* published in the August 28, 1998, *Federal Register,* identified 28 research programs within the following 8 major research areas:

- Natural Resources and the Environment
- Nutrition, Food Safety, and Health
- Animals
- Pest Biology and Management

- Plants
- Markets, Trade, and Rural Development
- Enhancing Value and Use of Agricultural and Forest Products
- Agricultural Systems Research

In addition, on January 4, 1999, a Supplemental Program Description was published that expanded existing programs in animal genetics and agricultural systems research and announced a new program to fund food safety research using an epidemiological approach.

A total of 2,736 research proposals were considered for funding in FY 1999. Thirty-one peer panels reviewed and ranked the proposals, evaluating them on scientific merit, the qualifications of proposed project personnel, the adequacy of the proposed facilities, and the relevance of the proposed project to long-range improvements in – and the sustainability of – U.S. agriculture.

Each peer panel was composed of individuals with the expertise required to review each proposal thoroughly and fairly. Proposals for Postdoctoral Fellowships, New Investigator Awards, and Strengthening Standard Research Projects were reviewed within the specified research program area. Proposals for Research Career Enhancement Awards, Equipment Grants, and Seed Grants were reviewed as a group.

Criteria for the selection of panel members included knowledge of the relevant scientific discipline, educational background, experience, and professional stature within the scientific community. The membership of each panel was carefully balanced to reflect diversity in geographical region, type of institution, type of position, and gender and minority status (see Table 1).

Additional expertise was brought to proposal evaluation by a number of scientists and other experts representing a wide variety of fields, who conducted *ad hoc* reviews. These reviews provided the additional expertise that made it possible to select the highest quality, most meritorious proposals for funding.

Table 1. Characteristics of NRI Peer Panels, FY 1999

Geographic Region	Number	Percentage
North Central[1]	92	27.4
Northeast[2]	60	17.9
South[3]	99	29.4
West[4]	85	25.3
Type of Institution		
Land-Grant	210	62.5
Public/Private	39	11.6
Federal	36	10.7
Industry/Other	51	15.2
Type of Position		
Assistant Professor	64	19.0
Associate Professor	109	32.4
Professor	97	28.9
Federal	36	10.7
Industry	12	3.6
Other	18	5.4
Gender/Minority Representation[5]		
Non-minority Males	213	63.4
Non-minority Females	78	23.2
Minority Males	34	10.1
Minority Females	11	3.3

[1]North Central region includes the following states: IA, IN, IL, KS, MI, MO, MN, ND, NE, OH, SD, WI.
[2]Northeast region includes the following states plus DC: CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT, WV.
[3]Southern region includes the following states: AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, TX, VA.
[4]Western region includes the following states: AK, AZ, CA, CO, HI, ID, MT, NM, NV, OR, UT, WA, WY.
[5]Minorities include Asians, African Americans, Hispanics, Pacific Islanders, and Native Americans.

More than 9,000 scientists contributed their time and expertise to the NRI proposal evaluation process in 1999. Participation in the panels and in writing *ad hoc* reviews provided many individuals the opportunity to gain experience in the review process and to become more familiar with the nature of the science supported by the NRI. The pool of *ad hoc* reviewers also provided a resource from which future panel members may be selected.

At the conclusion of the review process, a summary of the panel evaluation and the written reviews were forwarded to the submitting investigators, providing them with critical assessments of their proposed research by recognized leaders in the appropriate fields. The reviewers' comments and suggestions also were important for purposes of refining the proposals for future resubmission.

Continuing a practice begun in 1993, nontechnical summaries describing each research project funded in FY 1999 will be published as *Abstracts of Funded Research* and submitted to the House and Senate Agriculture Appropriations Committees. This publication is also available via the Internet on the NRI home page (*www.reeusda.gov/nri/*).

Grantsmanship Workshops

NRI program staff conducted a number of workshops in FY 1999 to increase applicants' and administrators' understanding of the philosophy and procedures of the NRI competitive review process. Early in FY 1999, staff held a grant-writing workshop in Kansas City, MO, as part of its ongoing practice of conducting a major grantsmanship workshop annually in one of the four regions (North Central, Northeast, South, and West) of the United States. The Kansas City workshop, cosponsored by the NRI and the University of Missouri Agricultural Experiment Station, focused on guidelines for preparing proposals, individual program descriptions, and recent funding statistics.

In addition, the NRI conducted individualized workshops at EPSCoR institutions, including Tuskegee University; at land-grant institutions, including the University of Minnesota; and at national meetings of scientific and/or professional societies, such as the Rural Sociological Society and the Plant and Animal Genome Symposium. NRI staff also spoke to regional research groups at the Agricultural Research Service and the Forest Service, and to international delegations of research administrators from Armenia and China.

Funded Research

In FY 1999, a total of 2,736 proposals were submitted to the NRI – approximately 6 percent greater than the number submitted in 1998 – requesting a total of $696,711,676 in funding, higher than in previous years. Awards totaling $111,785,962 were made to the highest ranked 690 proposals submitted to the NRI (see Table 2; number reported is grand total less awards to be determined).

The success rate (in terms of number of proposals funded and excluding conferences, supplements, and continuing increments of the same grant) was 24.7 percent, which is comparable to figures for FY 1998 and FY 1997. The average grant award for new standard research projects (excluding Research Career Enhancement Awards, Equipment Grants, Seed Grants, conferences, continuing increments, and supplements) in FY 1999 was $165,224 for 2.2 years. (For FY 1998, the comparable figures were $146,666 for 2.3 years.)

The NRI provided funds totaling $189,101 in partial support of 25 conferences in FY 1999. These conferences brought scientists together to identify research needs, update one another on research information, and/or advance an area of research important to U.S. agriculture.

In FY 1999, the NRI provided funds totaling $18,933,478 in Agricultural Research Enhancement Awards. This support included Postdoctoral Fellowships, New Investigator Awards, and Strengthening Awards (see Table 3).

Crosscutting Areas

A number of research topics of major importance to USDA involve several research areas or programs. NRI support for these crosscutting program areas in FY 1999 is indicated in Table 4.

The data show the total amount of funding from all research areas for a specified research topic. For example, the Water Quality area includes projects from the Water Resources Assessment and Protection Program as well as projects from other programs relevant to water quality such as Soils and Soil Biology. The Integrated Pest Management area includes projects funded from the programs on Biologically Based Pest Management; Entomology and Nematology; Plant Pathology; and Weed Biology and Management. The $8.1 million funding allocation for sustainable agriculture represents projects identified from many NRI programs, including the Agricultural Systems Research Program, that are directly relevant to sustainable agriculture. This

Table 2. NRI Funding Allocations,[1] FY 1999

Research Area/Program	Number of Grants	Total Dollars Awarded
Natural Resources & Environment		
Plant Responses to the Environment[2]	24	$3,698,389
Ecosystem Science	19	4,871,500
Water Resources Assessment and Protection	24	4,420,500
Soils and Soil Biology	19	4,257,500
Totals	**86**	**$17,247,889**
Nutrition, Food Safety, & Health		
Improving Human Nutrition for Optimal Health[3]	26	4,625,233
Food Safety	25	4,061,942
Epidemiological Approaches to Food Safety	9	5,312,072
Totals	**60**	**$13,999,247**
Animals		
Animal Reproductive Efficiency	29	4,554,818
Animal Health and Well-Being[4]	57	11,140,731
Animal Genome and Genetic Mechanisms	20	6,076,755
Animal Growth, Development, and Nutrient Utilization	18	3,226,346
Totals	**124**	**$24,998,650**
Pest Biology and Management		
Entomology and Nematology	43	6,395,000
Plant Pathology	32	5,017,815
Biologically Based Pest Management	15	2,310,675
Weed Biology and Management	9	1,312,188
Totals	**99**	**$15,035,678**

Research Area/Program	Number of Grants	Total Dollars Awarded
Plants		
Plant Genome	19	4,324,913
Plant Genetic Mechanisms	28	4,518,500
Plant Growth and Development	35	5,508,000
Nitrogen Fixation/Nitrogen Metabolism	15	2,300,000
Photosynthesis and Respiration[5]	16	2,271,020
Totals	**113**	**$18,922,433**
Markets, Trade, & Rural Development		
Markets and Trade[6]	24	1,993,000
Rural Development	14	1,700,000
Totals	**38**	**$3,693,000**
Enhancing Value and Use of Agricultural and Forest Products		
Food Characterization/Process/Product Research[7]	27	3,949,541
Non-Food Characterization/Process/Product Research	17	2,344,605
Improved Utilization of Wood and Wood Fiber	19	2,561,018
Totals	**63**	**$8,855,164**
Crosscutting Programs		
Agricultural Systems	16	3,507,366
Strengthening Programs	88	3,426,535
Totals	**104**	**$6,933,901**
Inter-Agency Programs		
Arabidopsis thaliana Genome Sequencing Project - Interagency[8]	1	100,000
U.S. Rice Genome Project - Interagency	2	2,000,000
Total Inter-Agency Programs	3	2,100,000
Awards To Be Determined[9]		880,713
Grand Total[10]	**690**	**$112,666,675**

[1]The content of this table varies slightly from tables provided in documents supporting the President's budget to Congress each year in the following ways: 1) while the documents supporting the President's budget include data only for funds from the 1999 appropriation, this table includes data on all awards from proposals submitted to the 1999 proposal cycle, regardless of the source of funds (as noted in the table) and 2) awards are arranged in this table under program area (to which proposals are submitted and reviewed) as opposed to relationship to appropriated budgetary lines.
[2]Includes 8 awards funded in whole or part with $1,603,584 from the FY 1998 appropriation.
[3]Includes 1 award funded in part with $4,679 from the FY 1998 appropriation.
[4]Includes 1 award funded in part with $22,155 from the FY 1998 appropriation.
[5]Includes 2 awards funded in whole or part with $293,664 from the FY 1998 appropriation.
[6]Includes 1 award funded in part with $3,091 from the FY 1998 appropriation.
[7]Includes 1 award funded in whole with $185,000 from the FY 1998 appropriation.
[8]Awarded through an interagency transfer to the National Science Foundation.
[9]As of November 27, 1999.
[10]Includes 13 awards funded in whole or part with $2,109,082 from the FY 1998 appropriation.

Table 3. Agricultural Research Enhancement Awards, FY 1999

Type	Number of Grants	Total Dollars Awarded
Postdoctoral Fellowships	20	$1,744,503
New Investigator Awards	38	5,422,328
Strengthening Awards		
Research Career Enhancement Awards	6	331,524
Equipment Grants	44	1,231,517
Seed Grants	38	1,863,494
Standard Strengthening Research Projects	56	8,340,112
Total Area Awards	**202**	**$18,933,478**

Table 4. Crosscutting Program Areas, FY 1999

Research Topic	Number of Grants	Total Dollars Awarded
Plant Genome	50	$8,997,144
Forest Biology	37	7,272,269
Global Change	57	9,850,726
Sustainable Agriculture	61	8,109,404
Animal Genome	24	6,633,644
Animal Health	93	17,609,822
Water Quality	33	4,159,881
Food Safety	49	11,148,599
Integrated Pest Management	74	10,700,101

figure is probably an underestimate since, in a broad sense, virtually all research supported by the NRI is germane to sustainable agriculture.

Research Dimensions

As noted earlier, research programs can be examined from perspectives such as type of investigation (fundamental or mission-linked) and organization of research approach (single discipline or multidisciplinary). The NRI defines *fundamental research* as that which tests scientific hypotheses and provides basic knowledge that allows advances in applied research and from which major conceptual breakthroughs are expected to occur. In contrast, *mission-linked research* is that which focuses on specifically identified agricultural problems which, through a continuum of efforts, provides information and technology that may be transferred to users and may relate to a product, practice, or process. *Multi-disciplinary research* is defined as work on which investigators from two or more disciplines are collaborating closely. These collaborations, where appropriate, may integrate the biological, physical, chemical, or social sciences. NRI funding in FY 1999 for these categories is shown in Table 5.

Table 5. Dimensions of NRI Research, FY 1999

Dimension	Total Dollars Awarded	Percent
Fundamental	$55,680,803	49.8
Mission-linked	56,105,159	50.2
Multi-disciplinary	48,509,287	43.4
Single discipline	63,276,675	56.6

Interagency Research

NRI program directors work closely with their research-funding counterparts in other Federal agencies to avoid duplication and maximize interagency cooperation. An example of cooperation is seen in the research that NRI funds jointly with other Federal agencies, including:

- The Interagency Metabolic Engineering Program, established in 1998 with the Department of Energy (DOE), the National Science Foundation (NSF), the Department of Commerce (DOC), the Department of Defense (DOD), the Environmental Protection Agency (EPA), and the National Aeronautics and Space Administration (NASA).

- The *Arabidopsis thaliana* Genome Sequencing Project, established in 1995 with NSF and DOE.
- The U.S. Rice Genome Sequencing Project, established in 1999 with NSF and DOE.

Each collaborative research program issues a single request for proposals, and agency representatives work together to assemble a panel of scientific peers to identify the most meritorious proposals. From this group, representatives of each agency select proposals that are the most germane to the mission of that agency. Thus, the NRI is able to attract researchers from a wide applicant pool to projects of importance to agriculture.

The National Research Initiative: Achievements

In FY 1999, the NRI funded 690 grants. This section provides examples of fundamental and mission-linked research targeted at problems important to the USDA mission, funded through the 31 panels and related to the five broad outcomes outlined in CSREES' *Government Performance and Results Act Strategic Plan*.

Outcome 1: An agricultural production system that is highly competitive in the global economy

Plants with broader tolerance to stress and sub-optimal environments. As the amount of usable land decreases, there is a need to engineer crops that can tolerate less than optimal environments. Dr. Michael Thomashow, Michigan State University, has discovered a family of closely related transcription factors in the model plant *Arabidopsis*, which regulate the genes whose function is to enhance plant-freezing tolerance. The transcription factors themselves are up-regulated by cold temperatures, so that a cold spell preceding a major freeze can protect the plants from frost damage. The new funding will allow Thomashow to investigate the signal transduction pathway that activates the expression of these key regulatory genes. Once this information is on hand, plants could be prepared for early frost by spraying the crop with an inducing factor. In addition, plant crops sensitive to frost might be rendered cold tolerant by gene transfer technologies.

Flooding results in the loss of millions of dollars in U.S. agricultural products. The damage is due to a critical lack of oxygen for metabolism. Dr. Mark Hargrove, a new investigator from Iowa State University, is studying a new class of hemoglobins distributed ubiquitously in plants that seem to be part of response to anaerobiosis. He predicts that these hemoglobins contribute to oxidation of NADH (Nicotinamide Adenine Dinucleotide, reduced form) and decrease the buildup of fermentation products when plant roots are flooded. His research will allow structure-function studies to be performed on these novel molecules, with the long-term goal of engineering crops with an improved ability to survive when oxygen is limited.

Circadian rhythms are implicated in the control of many plant processes, including flowering and growth. An ability to manipulate these rhythmic metabolic processes could allow crops to be productive under environmental conditions that might otherwise be unsuitable for worthwhile cultivation. Dr. Elaine Tobin at UCLA has discovered that a protein kinase, known as CK2, binds and modulates the activity of a transcription factor essential to the operation of the circadian clock that triggers flowering in the model plant *Arabidopsis thaliana*. She now seeks to understand how the two proteins interact and how the downstream events resulting from this association might be controlled.

The roots of weediness. When N_2-fixing leguminous crops such as soybeans are grown on soils low in nitrogen, one would expect weeds to be at a distinct competitive disadvantage for much of the growth season. Yet certain weed species seem able to thrive under such conditions. They must either obtain the nitrogen they need from the crop plant itself or else have a specialized root system that provides a highly efficient nitrogen uptake. Dr. Thomas Ruffy and colleagues at North Carolina State University and Eton College will use magnetic resonance imaging (MRI) to provide detailed maps of root growth and development within soils under different growing conditions. This team of scientists will also be able to follow the adjustments that occur when the roots of the weed are near the roots and nodules of a soybean plant. In addition to providing basic information about how weeds exploit their environment, such research may identify soybean cultivars that suppress weed growth by limiting the availability of nitrogen to their field competitors. The study is the first application of the MRI technique – so well known in medicine – to studies on plant growth.

Apoptosis in plants induced through a fungal toxin. Apoptosis, otherwise known as programmed cell death, is currently one of the hottest subjects in animal biology, but it has received surprisingly little attention in plants. Thomas Wolpert, Oregon State University, has found that a toxin known as victorin, which causes Victoria Crown Blight of oats, induces what appears to be apoptosis in cells from blight-sensitive plants. Wolpert's new studies will be to evaluate the targeting of victorin to the mitochondrion and to determine whether the death process that ensues mimics the classical progression of apoptosis in animal cells. The goal of the work is to identify ways to avoid the damaging effects of the toxin.

Fish immune systems, a key to controlling disease. Aquaculture is one of the most rapidly growing areas of agriculture; predictably, intensive fish farming is under threat from new diseases. If not properly controlled, such epidemics could rapidly decimate the industry. To make matters worse, present knowledge of the natural immune systems of fish is rudimentary. The species most studied in this regard is the channel catfish, the most important farmed species of fish in the U.S. Drs. V.G. Chinchar and N.W. Miller at the University of Mississippi Medical Center in Jackson have defined several key elements of the immune response in catfish. They propose to extend their studies to determine whether the catfish can generate cell-mediated responses to viruses. Such work could pave the way to the rational development of vaccines that will protect fish from viral disease.

Gene discovery through expressed sequence tags. The discovery, characterization, and subsequent exploitation of genes that are important to agricultural productivity will underpin efforts to maintain U.S. competitiveness in the global market and to address predicted food shortages in the next century.

Traditionally, gene discovery programs have followed a "one gene at a time" approach, which is costly, time consuming, and often ineffective. In the age of genomics, a variety of new approaches is being tried. One is to determine the complete DNA sequence of an organism – a huge endeavor and presently only practicable for a few organisms that have sizeable genomes. It is for this reason that the NRI, in joint efforts with other agencies and with international consortia, is supporting the sequencing of the entire genomes of *Arabidopsis thaliana* (120 Mb) and rice (430 Mb), which are "models" for important broad leaf and cereal crops, respectively.

A more affordable solution to gene discovery in crops with even larger genomes than rice - such as barley (5000 Mb) and wheat (16,000 Mb) - is to develop expressed sequence tag databases, which will provide a wealth of information in a short time. This year, the NRI has funded a group of scientists working cooperatively at four different institutions (Dr. Timothy Close, University of California, Riverside; Dr. Rod Wing, Clemson University; Dr. Andris Kleinhofs, Washington State University; and Dr. Roger Wise, USDA-ARS-Iowa State University) to produce high-quality normalized cDNA libraries from important stages in the development of barley plants. The group will then sequence the ends of at least 50,000 as ESTs (expressed sequence tags), prioritize them according to presumed function, and position the most important genes on a map.

Analogous studies have been funded by the Animal Genome project for two farm species, cattle and pig, whose genomes are comparable in size to that of the human (10,000 Mb). Dr. Harris Lewin, University of Illinois, and Dr. James Womack, Texas A & M University, will sequence 25,000 such ESTs from normalized cattle libraries and place at least 1,000 of these on a radiation hybrid panel. A similar number of ESTs will be produced from female reproductive tissues of the pig by Dr. Christopher Tuggle, Iowa State University, and his colleagues at the Universities of Missouri, Iowa, and Nebraska. ESTs will be useful not only in mapping economically important traits and in identifying novel genes but also in designing microarrays to view the complex changes in gene expression that occur as a plant or animal develops or responds to changing environmental conditions. Such arrays are among the basic tools employed in the newly emerging area of functional genomics.

Gene discovery and animal health. Neosporosis can cause abortion and developmental defects in cattle and is a major cause of economic loss in the dairy industry, particularly in California. In order to develop effective vaccines and treatments, targets for immunological and pharmaceutical intervention need to be identified. Unfortunately, relatively little is known about the causative agent, *Neospora caninum.* To rectify this situation, Dr. David Sibley at Washington University, St. Louis, will generate a database of 25,000 randomly selected cDNAs from which it should be possible to identify the major surface and secretory antigens of this pathogen. These sequences, in turn, can then be used to select antigens for vaccine development.

Several successful proposals in the area of animal health focused on the virulence genes that allow certain bacterial strains to become successful pathogens or even to switch hosts. Defining these factors will not only provide insight into the underlying basis of the disease but should also facilitate efforts to develop effective vaccines and other treatments. Drs. Jeffery Miller and Peggy Cotter, at the UCLA School of Medicine, are studying the gram negative bacterium *Bordetella bronchiseptica*, a respiratory pathogen that infects many different mammals and is responsible for much economic loss in the swine industry. The infections respond poorly to antibiotics, and commercial vaccines need improvement. The research will concentrate on a genetic locus encoding several genes whose protein products seem to target host cells during persistent infections and possibly cause a local immunosuppressive effect.

Vitamin A and enhanced reproductive efficiency in livestock. Assisted reproductive procedures, such as superovulation, in-vitro maturation and in-vitro fertilization of oocytes, and somatic cell nuclear transfer, are all important but relatively inefficient technologies. Dr. James Godkin at the University of Tennessee has provided compelling evidence that administering vitamin A, in the form of retinol, to healthy non-nutritionally deprived ewes during superovulation greatly improves the competence of the resulting embryos. In addition, he has shown that retinol supplementation of culture medium provides a remarkable beneficial effect on the ability of bovine embryos to advance to the blastocyst stage in-vitro. Among the proposed new studies, Godkin will determine whether the apparently superior embryos resulting from such retinol treatments also lead to better pregnancy outcomes and to an improved ability to survive cryopreservation. Although vitamin A has long been recognized as essential in reproductive processes – particularly for embryogenesis and healthy gamete formation – an impact on the very earliest stages of embryonic development has not been well documented. The studies may provide a means for improving reproductive efficiency in farm animals and other mammalian species through the use of vitamin A.

Outcome 2: A safe and secure food and fiber system

Listeriosis, an increasing problem in food safety. Listeriosis is an often-fatal foodborne disease caused by *Listeria monocytogenes*. The highest risk foods are ones that are ready to eat and are stored at refrigerated temperatures for long periods. The ability of this organism to out-compete other bacteria on minimally processed foods, particularly at low pH, and to grow at low temperatures has become a major concern of the food industry. Three NRI-supported projects address these issues. Drs. Frederick Breidt and Roger McFeeters, USDA-ARS Food Science Research Unit at Raleigh, NC, will examine the abilities of other microorganisms found on food to out-compete *L. monocytogenes*. The group will establish simulation models to assist the development of biocontrols over a broad range of temperatures. The other two projects, one by Drs. Brian Wilkinson and Philip Morse of Illinois State University and the second by Dr. Thomas Montville and colleagues at Rutgers University, will examine the membrane properties that appear to provide *L. monocytogenes* with a growth advantage over competing organisms at low temperatures.

Avoiding nut allergies. The United States is the largest producer of walnuts and almonds in the world. However, an estimated 0.5% of the population is allergic to tree nuts and can develop serious illness, or even die, when they consume (and sometimes even breathe around) tree nuts or products derived from them. Drs. Shridar Sathe and Kenneth Roux at Florida State University are developing immunoassays for detecting these potentially life-threatening allergenic proteins in foods that are not necessarily known in advance to contain the allergens. The research will also gauge the efficacy of steps to remove the proteins during processing. It is expected to be a model for future studies on other tree nut proteins.

Barriers to sales of irradiated food. Currently, little irradiated food is sold in grocery stores – even though irradiation has been shown to improve food safety, quality, and shelf life. However, grocers concerned about adverse effects on customer relations resulting from negative advertising by consumer advocacy groups are hesitant to offer irradiated food to their customers. A project by Dr. Steven Sapp, Iowa State University, will assess the ability of retail food stores with nationwide visibility to sell irradiated food without experiencing adverse customer relations. To allow reasoned decision making by consumers and a fair market test of irradiated food, this project will develop educational materials based on accurate scientific information that will address the issues raised by consumer advocacy groups in anti-irradiation media messages. The bottom line is that if customers can overcome their adverse reactions to irradiated food then food safety can be improved through the more widespread use of this technology.

Pure beef? The fraudulent or unintended mixing of beef with pork, and related forms of meat adulteration, are major concerns for consumers and inspectors alike. Drs. Peggy Hsieh and Fur-chi Chen at Auburn University are developing methods to distinguish proteins from different animal species, even after the meat has been cooked. They will use species-specific monoclonal antibodies as the basis for rapid, economical, and reliable tests for adulterated meat. Their work will be invaluable for guaranteeing quality control, for maintaining labeling standards within the industry, and for assuring consumer confidence at the grocery.

Food safety epidemiology: from farm to table. Nine NRI awards were made for multi-disciplinary epidemiological studies relating to food safety. Among them was a proposal by Dr. Ronald Weigel and colleagues at the University of Illinois aimed at identifying points within swine production facilities where salmonella infections are most likely to occur. Another by Dr. Thomas Bessers and co-workers at Washington State University has the goal of reducing the prevalence of cattle excreting enteropathogenic bacteria, such as *E. coli* 0157:H7 and *Campylobacter* species, at the time of slaughter. A third proposal from a group associated with the University of Georgia, headed by Dr. John Maurer, will be studying the spread of antibiotic-resistant strains of salmonella during poultry processing. These large grants will provide the information that producers, processors, and retailers need to design measures to prevent food contamination.

Cryptosporidiosis: a disease of cattle (and of people). Cryptosporidiosis is an economically important diarrheal disease of neonatal calves caused by the protozoan *Cryptosporidium parvum*. The disease can also be life threatening in humans who have lowered immunity thresholds. There are presently no effective vaccines or treatments. Dr. L.E. Perryman of North Carolina State University has immunized pregnant cows against a surface antigen of *C. parvum* and demonstrated that protective antibodies enter colostrum (first milk) and can therefore be transferred to calves. This work will be extended in his new grant to test the relative effectiveness of three distinct single-dose immunization methods. The one that provides the best immune colostrum will be developed as an immunization protocol for the livestock industry, thereby reducing disease in calves and limiting disease spread through fecal waste.

Outcome 3: A healthy, well-nourished population

Role of fish oil fatty acids. Numerous epidemiological studies have shown that the consumption of fish containing the long chain fatty acids, eicosapentaenoic acid and docosahexaenoic acid, is associated with a decreased risk of cardiovascular disease. Because oxidation of low-density lipoprotein (LDL) is thought to play a causal role in arteriosclerosis, Dr. Rosemary Wander, University of North Carolina, Greensboro, has developed the hypothesis that the fish oil fatty acids make LDL less susceptible to oxidation and less prone to cause pathophysiological responses in blood vessels. Her grant from the NRI will be to test this hypothesis in a clinical trial on postmenopausal women, who as a group are at particular risk for developing cardiovascular disease. This research may indicate the proper ratio of the two fatty acids that should be included in dietary guidelines, as well as the precise role these compounds play in maintaining health.

Fructose and obesity. Obesity is a risk factor for the development of Type-2 diabetes, hyperlipidemia, and hypertension. The prevalence of obesity has increased progressively over the past 20 years. Dietary intake of the sugar fructose has followed a similar trend. Whereas glucose stimulates secretion of the hormones insulin and leptin, both of which provide information about energy status to the central nervous system, fructose does not. Drs. Peter Havel and Nancy Keim of the Universities of California at Davis and San Francisco, respectively, believe that energy consumed as fructose essentially bypasses many of the mechanisms that maintain homeostasis. They point out that comprehensive long-term studies of the effects of fructose consumption have not been conducted in either humans or non-human primates. As a consequence, the two investigators will conduct trials in which moderately obese, non-postmenopausal women will consume diets high in either free fructose or free glucose. A range of parameters – including appetite, circulating levels of leptin and insulin, adiposity, serum lipids, and energy expenditure – will be measured to determine how the women differ in their responses to the two sugars.

Eat your broccoli! Cruciferous vegetables, such as broccoli and cabbage, contain high concentrations of anti-cancer compounds derived from glucosinolates. During processing and home preparation, these compounds are transformed into either bioactive isothiocyanates or inactive nitriles. The goal of a project by Drs. Elizabeth Jeffery and Matthew Wallig, University of Illinois, is to determine processing and food preparation steps for broccoli that favor the production of the isothiocyanates and thereby enhance the health benefits of this vegetable.

Outcome 4: Greater harmony between agriculture and the environment

Ammonia metabolism and pollution. Ammonia plays a central role in the efficiency of nitrogen utilization by rumen bacteria and hence in nitrogen metabolism and economy of the ruminant animal. Ammonia is important in ruminal nitrogen metabolism because it is the terminal end product of protein degradation, as well as a principal precursor of microbial protein. Feeding diets with excessive degraded protein results in the accumulation of ruminal ammonia more rapidly than it can be incorporated into microbial protein. More efficient capture of ammonia by bacteria in the gastrointestinal tract will reduce both nitrogen loss and environmental pollution. Dr. Roderick Mackie, University of Illinois, is conducting research to understand the biochemical and genetic properties of key ammonia assimilating enzymes in the Gram-positive, cellulolytic, rumen bacterium, *Ruminococcus flavefaciens*. More efficient fixation of nitrogen into bacterial cells will reduce nitrogen excretion and assist in developing animal production systems that are sustainable, both environmentally and economically.

Ecological health of plant communities. Many of the more vexing questions facing U.S. and world agriculture need to be addressed at the level of whole ecosystems. Only in that manner can strategies be devised to manage natural resources successfully and to minimize damage to the environment from agricultural practices. Several new projects will address this important but relatively neglected topic. Drs. Mario Biondini and Carolyn Grygiel, North Dakota State University, are examining how diversity in plant communities might (or might not) affect stability and long-term productivity of Great Plains grasslands. Dr. Peter Vitousek, Stanford University, is evaluating how several different exotic species are disrupting tropical forest ecosystems in Hawaii. Further east, there is concern that oaks in deciduous forests are regenerating poorly. Dr. Walter Carson and co-workers, University of Pittsburgh and the USDA Forest Service, have designed an innovative experiment to search out the causes of the demise of the oaks. In another study of forests, Dr. Thomas Parker and colleagues at San Francisco State University are studying the below-ground system of mycorrhizal fungi to determine how it affects forest succession in general and the establishment of Douglas fir in particular.

Exotic plant invasions. Exotic plant invasions are unfortunately ubiquitous throughout the agricultural landscape, but the relationship between biological diversity and invasion by exotic plant species has rarely been tested experimentally. A project by Dr. Scott Meiners at Rutgers University will examine invasions by exotic plant species into abandoned agricultural fields to address two basic ecological questions: First, does community diversity influence the invasion of exotic plant species? And, second, does invasion by exotic plant species affect community diversity? Either could account for the observed destructive impact on diversity when exotic species are present. These questions must be addressed if practical management strategies for disturbed lands are to be developed. Meiners' approach will be to utilize a data set on field succession that has been acquired over a 40-year period at a single site. This data set is the longest known continuous study on succession and provides a unique opportunity to study a series of exotic plant invasions over time.

Control of pests through biocontrol. The imported fire ant *Solenopsis invicta* is one of the most abundant insect pests in the Southeastern United States. With average densities of 1,500 to 3,500 ants/m^2, these pests are virtually ubiquitous in parks, pastures, yards, and cultivated fields. Fire ant densities in the United States are about five times higher than those found within its natural range in South America. Escape from numerous natural enemies left behind in South America is a likely explanation for this difference. Dr. Sanford Porter, at the USDA-ARS Center for Medical, Agricultural and Veterinary Entomology in Gainesville, FL, is pursuing a biological control method that employs several species of phorid flies imported from South America. Porter has learned to mass rear the flies, has demonstrated that they are safe for release, and has proved that they can survive and multiply on imported fire ants in the U.S. With funding from the NRI, Porter proposes to determine the long-term impacts of these flies on fire ant populations at a dozen sites in north Florida. He will also monitor rates of fly dispersal from these test sites. The hope is that the release of these flies and other natural enemies will reduce fire ant densities to levels similar to those in South America. Successful fire ant biocontrol agents would reduce the need for expensive quarantine measures designed to prevent further northward and westward expansion of this invasive pest.

Vegetable crops, particularly in Southern states, are plagued by multiple diseases and pests, which are traditionally controlled by applying at least one fungicide, one insecticide, and often also a copper-based anti-bacterial formulation several times during the season. Basic research, much of it funded by the NRI, has demonstrated that leaf chewing by insects and infection by various fungal and bacterial pathogens result in the production of secondary compounds by the plant host that offer protection. These induced compounds are now available commercially and can be applied to activate resistance before infection. Research by Drs. G.W. Zehnder and J.W. Kloepper, Auburn University, will use combinations of these substances in controlled studies on cucumbers. They will determine whether the use of one treatment neutralizes or even antagonizes the effects of another, and how insect feeding behaviors are altered by the combined treatments. An understanding of these interactions is needed if the various induced-resistance technologies are to be used together to provide broad-based protection against pathogens and pests.

Insect invasions – how to control them. Biological invasions threaten the integrity of ecosystems worldwide, but exactly why so many invasive species are successful is poorly understood. Dr. Jocelyn Millar and colleagues at the University of California, Riverside, are in the unusual position of following an invasion in actual progress, in which a recently introduced insect pest, a wood-boring beetle called *Phorocantha recurva*, is in the process of displacing a well-established relative, *P. semipunctata*. Both beetles feed on Eucalyptus trees, and both are parasitized by an introduced wasp, *Avetianella longoi*. The researchers are studying what factors tip the competitive balance in favor of the foreign beetle and whether the parasitic wasp is capable of controlling this invader. The study will help us understand the complex forces shaping the invasion as it radiates rapidly from southern California.

Like the fire ant, the invasive Argentinian ant *Linepithema humile* appears more limited in its spread within the U.S. by abiotic factors such as temperature and moisture than by competition from native species. Dr. David Holway, University of California, San Diego, is exploiting the ease with which this ant can be grown in confinement. He will combine field and laboratory research to study the relationship between colony size and ambient temperature. The experiments are expected to yield insight into why this ant is so successful as an invader and to provide information that might allow design of control strategies.

One other method for controlling insects is to introduce genetically modified ones – for example, ones that can pass on a lethal mutation into the wild population so that the ability of the species to reproduce and spread at will is compromised. A difficulty confronting such a strategy is that there is a lack of vectors that can be used to transform insects and provide subsequent stable germ line transmission of an introduced gene. That situation may be changing as a result of the work of Dr. Alfred Handler, an ARS scientist at Gainesville, FL, who is extending his work on transforming the Mediterranean fruit fly to other insects. He has developed a vector based on a transposon (*piggy*Bac) isolated from the cabbage looper moth. This vector has the potential to provide gene transfer and germ cell transformation in many different insect systems.

Another approach to modifying natural populations of insects is to release an infective pathogen targeted to the pest species. Intracellular bacteria of the genus *Wolbachia* may provide an exciting new tool for controlling insects in such a manner. These bacteria compromise the reproductive cycles of the insects they infect, causing effects such as sterility and feminization. Dr. Stephen Dobson at the University of Kentucky will evaluate the potential of *Wolbachia* to modify field populations of mosquito species and thereby provide an alternative to chemical methods for controlling this pest.

Outcome 5: Enhanced opportunities for farmers, ranchers, and rural people and communities

Trees with less lignin. Can trees be developed that contain modified lignins so that they can be converted more readily into pulp for papermaking and other materials? If the answer is yes, then it might soon be possible to provide higher yields of pulp with less energy input, conserve forests, and lower the amount of lignin and extracting chemicals present in water discharged from pulp mills. Mutations within the lignin biosynthetic pathways – either occurring naturally or derived through transgenic technologies – are providing a range of novel varieties of plants and trees with modified cell wall composition. In one of these projects, Dr. John Ralph of the ARS Dairy Forage Research Center is examining lignins formed in such genetically altered plants so that future genetic manipulations can be less empirical and more rationally applied to the needs of the paper industry.

Drs. D. Dimmel and J. Mackay of the Institute of Paper Science & Technology have developed a variety of loblolly pine deficient in the lignin biosynthesis enzyme, cinnamyl alcohol dehydrogenase (CAD). Wood from this tree is relatively easy to delignify, but the trees have poor growth characteristics. In their new proposal, the two scientists will examine the pulping characteristics of woods from trees only partially deficient in CAD, which grow at faster rates than normal trees and have better economic potential than the full-blown mutants.

In the third proposal, Dr. Vincent Chiang and colleagues at the Michigan Technological University have found that when lignin synthesis is down-regulated in aspen trees, cellulose deposition increases in a compensatory manner. The scientists now plan to increase the rate of cellulose synthesis in aspens with already lowered lignin content even further by introducing an additional cellulose synthesis gene into the plants.

New products from plants. Dr. Kan Wang and colleagues, Iowa State University, seek to develop a feed-based oral vaccine for swine and other livestock by expressing the heat labile enterotoxin of *E. coli* coupled to an adjuvant in corn kernels. Although the concept of mucosal immunity induced by edible vaccines is not new, this may represent the first effort to target an immunogen to corn, an obvious choice for livestock vaccines.

The production of various useful chemicals from starch first requires that the polymer be converted to sugars. Drs. Gregory Zeikus and Clair Vieille, Michigan State University, have been awarded a grant to continue work on improving starch bioprocessing enzymes (amylosaccharidases) isolated from a thermophilic bacterium, *Pyrococcus furiosus*, for industrial use. The plan is to engineer enzymes that are low pH tolerant, thermostable, and highly soluble, and that lack a requirement for calcium ions in order to improve their utility in starch processing.

Genetic improvement in oysters. Farming of the Pacific oyster *Crassostrea gigas* accounts for more than one-third of U.S. oyster production and is important to rural economies suffering contractions in fishing and logging. Dr. Dennis Hedgecock, University of California, Davis, has been funded by the NRI to map economically important traits in oyster species. He has developed several inbred lines for experimental study of the genetic and physiological basis of hybrid vigor and for testing crossbreeding as a means of improving growth of farmed oysters. He is now poised to construct a genetic linkage map using nine of these reference families, which will be used, among other purposes, for mapping genes that affect growth.

Restriction of trade through import quotas. Two-tier tariff-rate import quotas (TRQs) were instituted as part of the Uruguay GATT Round with the purpose of increasing market access for protected agricultural commodities through quotas, while tariffs were designed to maintain support to farmers. Although import quotas are binding (they will not be allowed to decline), and all tariffs (except for some 1st tier tariffs) cannot increase, there remain differences in how the quotas and tariffs are managed relative to the setting of their absolute or relative levels. As a consequence, there is no uniformity between countries, and some appear to be more restrictive than others. The purpose of a proposal by Dr. Harry de Gorter, Cornell University, is to evaluate the extent of differences within TRQ and to analyze how these differences affect trade.

Economics of hog production. A study by Dr. John C. Beghin, Iowa State University, will examine the relationship of the new, large, vertically coordinated hog production operations and the mounting environmental regulation of hog wastes. The interface of farm size, cost of environmental regulation compliance, and production locations will be assessed. The main goal of this research proposal is to examine how the above parameters will affect competitiveness of the domestic hog production industry in the U.S. and international markets.

Private sector insurance for farm operations? A study by Hong H. Wang, Washington State University, will examine whether or not it is feasible or possible to have the private sector rather than the Federal Government offer crop insurance to farmers. Because agriculture is so dependent on the vagaries of weather and other factors, farming is a high-risk business. Risk management strategies – of which crop insurance is one of the most important – are required for long-term, sustainable, successful farming. Wang argues that the key to determining whether or not private insurance is feasible is to assess the degree to which insurance providers can accomplish risk pooling. Thus, an insurance company might be able to offer policies over a sufficiently broad geographical area that, in any particular year, insurance risks are evened out.

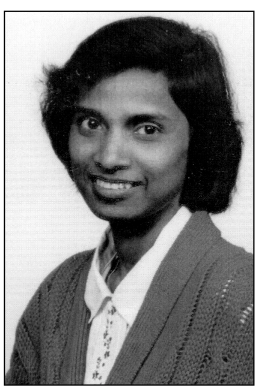
Economic position of women in rural communities. Dr. Bradford Mills, Virginia Polytechnic Institute and State University, will assess how recently enacted welfare reforms are influencing the job market and the degree of poverty within households headed by single women in rural areas of the South. A second project, headed by Dr. Carolyn Sachs, Pennsylvania State University, will examine the role of women from rural communities in the actual practice of farming or farm organizations and jobs unrelated to farming and in the informal economy. The goal is to estimate the overall economic contribution of women to agriculture.

NRI Investigators Elected to the National Academy of Sciences

Dr. Joanne Chory, who was elected to membership in the National Academy of Sciences in April 1999, is continuing her NRI-funded work on the plant steroid hormone brassinolide, which plays a role in controlling plant size. She has recently cloned a putative membrane-bound receptor and two helix-loop-helix transcription factors that are activated immediately following exposure and has identified a vascular ATPase, which seems to be a downstream "effector" molecule. Chory is now in a position to develop transgenic plant lines with altered levels of brassinolide to determine how the brassinolide receptor functions and to understand the means whereby the hormone alters transcriptional activity. Her work will provide new strategies for modifying plant size and agricultural yield.

Dr. James E. Womack, who was elected to membership in the National Academy of Sciences in April 1999, is coordinator of the USDA Bovine Genome Initiative and a world leader in bovine gene mapping. His joint 1999 grant with Dr. Harris Lewin on the production and mapping of expressed sequence tags (ESTs) represents one of five projects funded through the new NRI initiative to provide tools for animal genome research to the scientific community. Womack's work has been funded continuously through Animal Genetic Mechanisms since the inception of this program in the mid 1980s. He is currently the W.P. Luce Professor of Veterinary Pathobiology and Genetics at Texas A & M University.

President's Early Career Award for Scientists and Engineers



In FY 1999, **Dr. Smita Mohanty** of the State University of New York, Stony Brook, received a Presidential Early Career Award for Scientists and Engineers in recognition of her research on the pheromone-binding protein of the silkworm and tobacco budworm. This award, for which she was nominated by the NRI, honors scientists and engineers who show exceptional potential leadership at the frontiers of knowledge during the 21st century.

A 1999 recipient of an NRI New Investigator Award, Mohanty is Assistant Professor with the Department of Biochemistry and Cell Biology. She was trained as a chemist at the University of Delhi, India, and carried out postdoctoral studies at the University of Washington, Seattle, where she became involved in Nuclear Magnetic Resonance (NMR) and other structural work on a drug-protein complex.

Mohanty's work will elucidate how the size, shape, and folding of a protein, which are important to sex pheromone reception, contribute to how the protein functions. Her research may lead to the design of compounds that could interfere with the pheromone reception, thereby disrupting mating in moths. Directed interference with pheromone binding to its primary target offers a unique and environmentally benign strategy for control of insects.

From Discovery to Practice: Success Stories from the Competitive Grants Program (CRGO/NRI) of the United States Department of Agriculture

Competitive research grants have been supported by USDA for more than 20 years, with the formation of the Competitive Research Grants Office (CRGO) in 1978 and the subsequent establishment of the NRI in 1991. Beginning this year, the NRI Annual Report features a selected number of stories about research supported by the competitive grants program. In each case, basic discoveries paved the way for important changes in the manner in which agriculture is practiced today. Each story illustrates the value of basic research but is also a lesson in patience and perseverance. Application is rarely immediate in its outcome. Discoveries today will have their outcomes only down the road. The NRI supports high-risk research, and only some of it can possibly hope to lead to the sort of breakthroughs that are illustrated in this series of stories. To neglect basic research is to neglect future competitiveness in agriculture at a time when farmers and ranchers are being asked to do more on less and less land.

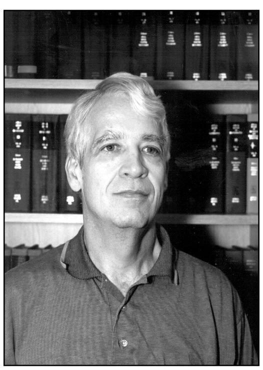


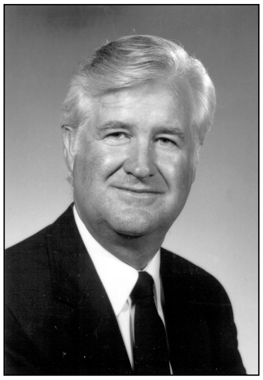
Photo credit: H.C. Aldrich, IFAS, University of Florida

Ethanol from Biomass
Dr. Lonnie Ingram, University of Florida

If renewable biomass sources are to supply tomorrow's energy needs, cost-effective technologies are needed. Dr. Lonnie Ingram and colleagues at the University of Florida have been developing different microorganisms in which useful traits for cellulose hydrolysis and sugar metabolism are combined with genes for ethanol production. With NRI support, genetically engineered *Escherichia coli* were developed to produce ethanol from all the monomer sugars that can be derived from plant cell walls. Subsequent awards have led to the integration of the ethanol production genes from *Zymomonas mobilis* into *E. coli* and the engineering of *Klebsiella oxytoca* for the simultaneous saccharification and fermentation of cellulose. More recent efforts are seeking to "improve" these microorganisms further, for example by engineering the secretion of an *Erwinia* endoglucanase in *E. coli* and *Klebsiella oxytoca*. The aim is to reduce the requirement for supplemental cellulases from fungi, which are costly. Other research is to develop ethanol-producing biocatalysts with increased resistance to toxic products generated during the chemical hydrolysis of lignocellulose components. These compounds, hemicellulose and lignin degradation products, currently must be removed by an expensive multi-step process.

While work continues to make the biomass conversion to ethanol more competitive, a milestone has been reached. On October 20, 1998, BC International broke ground in Jennings, Louisiana for a commercial-scale plant to produce ethanol from agricultural waste. The plant, which has the capacity to produce 20 million gallons of ethanol per year, will run on bagasse (a residue from sugarcane refining) but has flexibility to use other feedstocks as well. This first-of-its-kind plant is based on the genetically engineered KO11 bacterium developed by Ingram and colleagues.

Ingram has received seven grants from the USDA competitive grants program to support his research, during which time he has been awarded several patents, including the 1991 landmark U.S. Patent number 5,000,000 – "Ethanol production by *Escherichia coli* strains co-expressing *Zymomonas* PDC and ADI-1 genes." He is currently Graduate Research Professor in the Department of Microbiology and Cell Science at the University of Florida, Gainesville.



Corn from Cells Instead of Seeds

Dr. Ronald Phillips, University of Minnesota

In the early 1970s, the laboratory of Dr. Ronald L. Phillips at the University of Minnesota was the first to regenerate complete corn plants from cells in tissue culture. This procedure has allowed the genetic engineering of corn, which is now having an impact on agriculture in the U.S. and around the world. The approach pioneered by Phillips and postdoctoral scientist Ed Green was also quickly adopted to achieve the regeneration of other cereals. Despite its current success, there were initially considerable barriers to applying the technology as a means for cloning genetically altered corn plants. Phillips quickly recognized that the plants derived from tissue culture were not exact genetic copies, as originally expected, but that variation was being induced by the tissue culture process. An understanding of the basis of this variation became an important goal since it was a drawback in the production of transgenic plants.

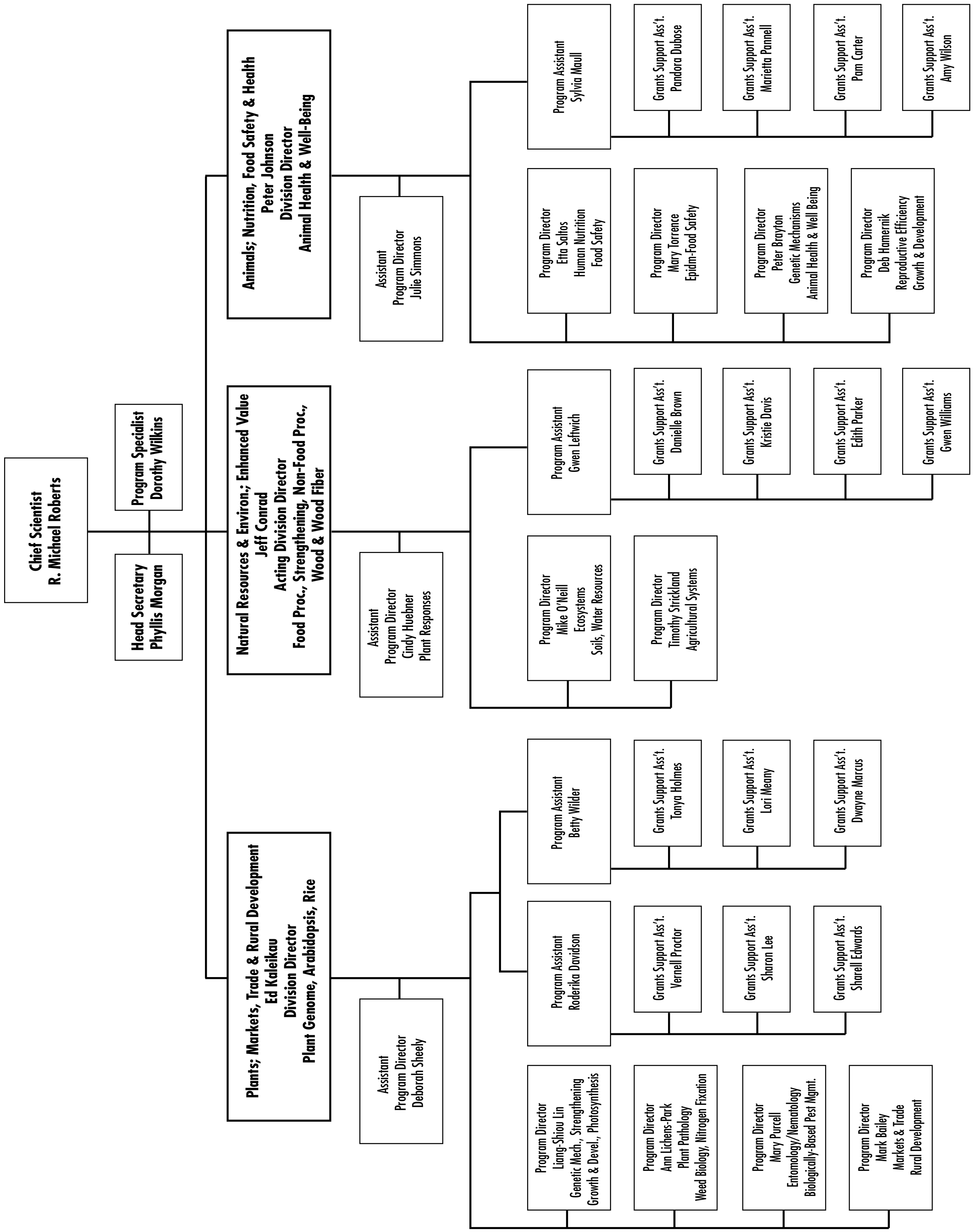
USDA funding enabled Phillips and colleagues to demonstrate that transposable elements were activated during tissue culture. Insertion of transposable elements could have accounted for the high rate of chromosomal breakage and the prevalence of single gene recessives, which were often sectored in different parts of the regenerated plant. Another cause of induced variation was due to major alterations in gene methylation patterns over large chromosomal domains.

Not every corn line has been effectively regenerated from tissue culture to produce fertile plants, but the most common genotype used by industry for introducing new genes traces back to the work of graduate student Chuck Armstrong in the Minnesota program. It is also now recognized that genetic variation will be induced by the tissue culture procedure. Therefore, short culture times and crossing the regenerated materials to elite lines are used to circumvent the problems. Tissue culture regeneration technology provided a major breakthrough leading to production of genetically engineered plants. Insect-resistant corn plants, for example, occupied about 20 million acres in the U.S. in 1999.

Phillips' work was first funded by the competitive grants program during its first round of applications in 1978. He was continuously supported through the program until he became NRI Chief Scientist (1996-1998). Phillips was elected to the National Academy of Sciences in 1991. He is currently Regents' Professor and McKnight Presidential Chair in Genomics in the Department of Agronomy and Plant Genetics at the University of Minnesota.

Appendix
Organizational Structure

National Research Initiative Competitive Grants Program



For current listing of programs and staff, please refer to the NRI website (http://www.reeusda.gov/nri) or call 202-401-5022